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Study of influence of two crust formation mechanisms to runoff generation by means of a new type portable rainfall simulator

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The effect of rainfall on soil infiltration rate (IR) and accordingly on runoff generation is being investigated for many years. A drastic reduction in IR is discerned in soil surface exposed to rain or sprinkler irrigation, the reason for this IR decrease is the formation of crust at the soil surface. Two complementary mechanisms are supposed to be responsible for crust formation: (a) physical disintegration of soil aggregates and their compaction caused by the impact action of the raindrops at the soil surface, (b) chemical dispersion and movement of clay particles beneath soil surface, where they lodge and clog the conducting pores. Agassi et al. performed a research in which distilled water (DW) with low electrolyte concentration and tap water TW with high electrolyte concentration were applied over four soil samples of different exchangeable sodium percentage (ESP) using RS. They found a dependence of IR decrease on both physical and chemical mechanisms of soil crusting. Experiments showed that crusts formed on soils with high ESP rained with the distilled water were much more stable, its permeability was very low and remained low in subsequent showers. These and other studies confirming obtained results were performed using Morin et al. rotating disc RS which was designed to be operated in laboratory with soil samples packed in 30x50cm trays. Rain simulation in laboratory conditions has a number of clear limitations in simulating real runoff generation. Therefore, in order to examine the effect of rainfall generation on natural soil it is important to use RS in the field conditions.

To meet the necessity of studying runoff generation in the field condition the new rainfall simulator was developed. Unlike the rotating disk RS system, where intensity

is determined by the rotating disk mechanism creating pulsing flow, the flow rate of the RS presented in this study is regulated by solenoid valve operated by an electric controller. Intensity changes according to the duration of valve opening and the time intervals between each spraying pulse. RS characteristic parameters such as water distribution, rain intensity, dropsize and drops velocity were analyzed and calibrated. The RS is capable to produce the rain with the same parameters simultaneously over two 2x1 m plots.

Since RS does not produce a continued rain but pulsed one, the first experiment was to estimate the influence of pulse break duration on runoff generation. For that purpose a series of field tests was performed with various pulse durations. It wasn't found a significant difference in runoff generation while showers with pulse duration less or equal of 12 seconds were applied, i.e. this regime may be considered as a continuous rain.

The objective of the field RS experiments was to evaluate the significance of each of two crust-formation mechanisms for the process of runoff generation for soils of low ESP. Simulated rainfall intensity of 29 mm/h was applied for all experiments. Experiments were carried out at the Mashash experimental runoff harvesting farm in the Negev desert (Israel).

The effect of drops impact was examined by covering the plot with a screen that absorbs most of raindrops kinetic energy (KE) thus prevents raindrops impact on soil surface. This screen was made of three layers of mosquito net that were stretched on 1.1x2.1m wooden frame and placed 15cm above the plot. The treatment was performed on three screened plots and eight control plots with simulated rain duration of 90min. Runoff at the screened plot arose with average delay of 8 minutes relatively the control plots. Final infiltration rate was reached for the control plots and not reached for the screened plots. The results show that influence of the physical crust formation mechanism is high and that rainfall energy and raindrop impact strongly affect runoff generation.

The effect of electrolyte concentration was examined by applying distilled water (DW) rainfall with electrical conductivity (EC) of $0.05 dSm^{-1}$ on the plots until final infiltration rate is reached. Four replicas of this experiment were performed and compared with eight control plot data (rained with tap water (TW)). In the beginning more rapid runoff intensity increase was observed in the experiments with DW than with TW though the STDEV then is high (3-10% in DW and 3-13% in TW). Nevertheless average final infiltration rate for both treatments was very close (12mm/h and 13 mm/h) and in both cases it was reached after 55min. So we found no significant effect of the electrolyte concentration of the applied water on runoff generation. Physical crust

formation mechanism was predominant in its influence on runoff generation.